

# Nuclear Technology -II

B.E. Sem. VIII [MECH]

(Elective – II)

## EVALUATION SYSTEM

	Time	Marks
<b>Theory Exam</b>	3 Hrs.	100
<b>Practical Exam</b>	–	–
<b>Oral Exam</b>	–	25
<b>Term Work</b>	–	25

## SYLLABUS

### 1. Recapitulations :

Atomic Structure; radioactivity; interaction of alpha, beta and gamma with matters; neutron reactions – fission and fusion energies; fission fertile and fissionable material, neutron reactions, neutron cross sections, fission process, fission products, fast neutron diffusion and slowing down of neutrons, moderating ratio, thermal neutrons, four factor formula, criticality equation, non-leakage probability, reflector, neutron lifetime, period, delayed neutron, positive and negative reactivity, temperature, power and void coefficients of reactivity, effect of isotopic purity of moderator, changes of coolant parameters on reactivity effects, advances in nuclear power reactors, different types of power reactors, secondary steam and with reheat and feed water heating, emergency power supply, power generation and distribution, dedicated power supply and power evacuation arrangements, principles of radiation protection, radioactive waste management, different uses of nuclear energy- research, test, isotope productions, agricultural, medicinal and industrial, regulatory aspect on the use of nuclear energy, nuclear energy scenario India.

### 2. Systems in nuclear reactor:

#### **Reactor fuels:**

Natural and enriched fuels, sources, merits and demerits of different fuels for reactor use, fabrication, handling of fuels and irradiated fuels, fuel management, storage, reprocessing of irradiated fuels.

#### **Reactor shutdown systems:**

Materials for reactor control and choices, liquid vs. solid shut down systems, design aspect- fall safe features, loading consideration, actuation methodology,

#### **Primary heat transport (cooling) system:**

Heat generation and distribution, Coolant characteristics, Selection of coolants, Coolant Circuit, Core thermal hydraulics, design aspects, radioactivity generation.

#### **Decay heat removal system:**

Functional requirements, Cooling circuits, Design aspects, Loading considerations, Passive features.

#### **Reactor structure :**

Core composition, Reflector, Reactor vessel, Safety vessel, Shielding – thermal, biological, Shield cooling system, Neutron flux monitoring and control, instrumentations,

#### **Moderator system:**

Materials, Selection, Design consideration, Circuit, Radioactivity aspects.

#### **Cover gas system:**

Purpose, Selection of material, Design considerations, Circuit.

#### **Reactor regulating system:**

Purpose, Methodology, Design considerations, Actuating mechanism

#### **Auxiliary cooling circuit:**

Functions, Design considerations, cooling circuit

#### **Containment and ventilation system:**

Functions, Types, Arrangement, Design considerations, loading , Testing

### **Conventional systems :**

Function, Design considerations and Arrangement for:

- (1) Secondary steam system: Boiler (generator) – Steam discharge and dump valves, Turbine, reheat, feed water heating; Condenser; Condenser cooling water system, polishing unit, Deaerator.
- (2) NDCT, IDCT, intake from and outfall to natural water source.
- (3) Electrical power supply: Classification of power, Emergency D.G. power supply system, Batteries, Generators, Switchyard, Transmission, Dedicated power source and evacuation systems.
- (4) Air conditioning
- (5) Control and instrumentation:  
Parameters and logics for reactor scram, Power regulation, Monitoring, display and recording systems, Main control room and Supplementary control room.

### **3. Reactor Design:**

Principles, Safety classifications, Seismic quality group, Loading considerations under normal operations, anticipated operational occurrences, design basis accidents such as earthquake, loss of coolant accident (LOCA), blackout, flood, missiles, operator error, dual failures as applicable, Safety features for server accidents, standards, software's verifications etc.

### **4. Nuclear power plants :**

Types – Thermal reactors: BWR, PWR, PHWR, GCR, APWR, AHWR etc. Fast reactors – Breeders; Fusion power; Off-land NPPs:- space power unit, nuclear ships, submarines  
Economies of NPPs: Various costs, ROI, Sizing, Operational characteristics, Tariff

### **5. Radiation protection and: Radioactive Waste Management (details):**

Radiation protection: Radiation hazard, Exposures, Exposure pathways, dose unit, measurement, radiation protection – CRP and other guidance document etc.

Radioactive Waste Management: Waste categorization, Generation, Handling of wastes – liquid, gaseous and solid, Short term / long term storage / disposed.

### **6. Reactor Stages and Safety Assurances :**

#### **6.1 Reactor Stages:**

1. Site Selection
2. Reactor construction and commissioning:
3. Operation and maintenance:  
Technical specifications for plant operations, Manrem budgeting and control, scheduled and unscheduled maintenance, Plant modifications, refurbishments.
4. Plant life extension program
5. Plant decommissioning:

#### **6.2: Nuclear safety assurance:**

1. Safety commitment by the utility.
2. Nuclear safety regulation: national body and International advising body (IAEA – International atomic energy agency under U.N.)
3. Nuclear safety documents: standards / codes, guides, manual, safety series, technical documents.
4. Regulatory consents for site selection, design, construction, stage wise commissioning from first criticality to commercial operations.
5. Periodic safety reviews, safety reviews for relicensing / reauthorization for operation.
6. Safety analysis: deterministic safety assessment, probabilistic safety assessment (PSA), regulating inspection and enforcement.
7. A retrospect in nuclear reactor accidents world over: root causes, lessons learnt, subsequent improvements in design and operations to prevent recurrence.
8. Plant performance records and reports, living PSA / risk monitors.
9. Public Awareness, public participation in granting regulatory consent to nuclear plant.

**Reference Books :**

1. NPP of Power Plant Engg. (*A.K. Raja, A.P. Srivastava & M. Dwivedi*)
2. An Introduction on Nuclear Engineering, A course in Power Plant Engg. (*Arora & Domkundwar*)
3. Nuclear Power Plant, Power Plant Engg. (Steam & Nuclear)- (*P.K. Nag*).
4. Nuclear Engineering (*Glasstone & Sesons*)

